Experience in Using Large-Area Detector Panels for Building a High-Sensitivity Small-Animal PET Scanner

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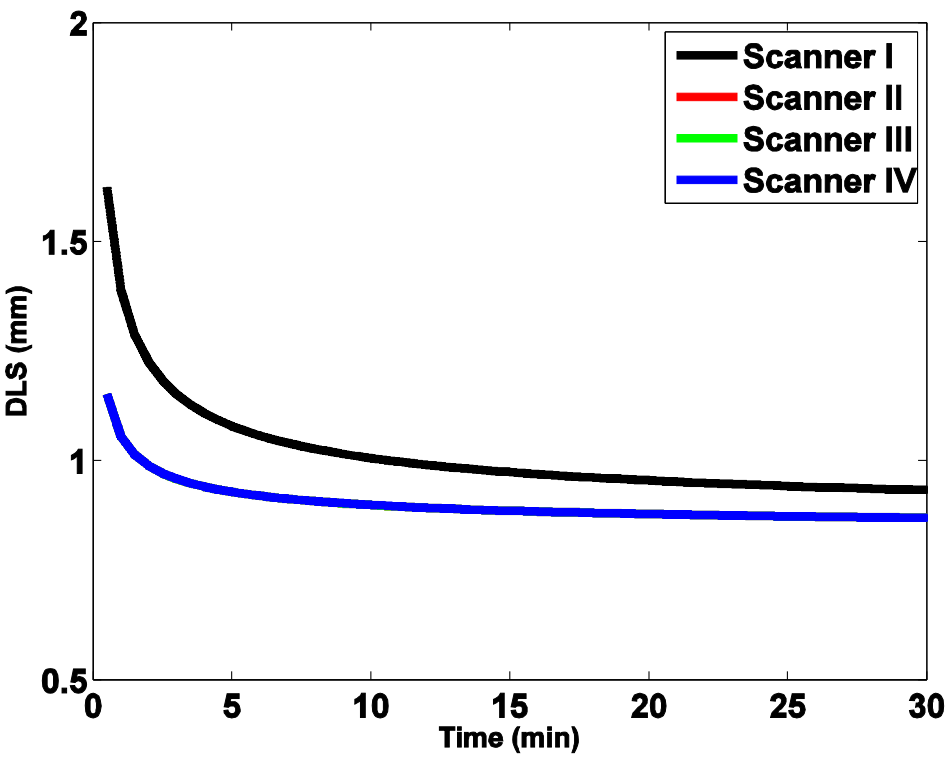
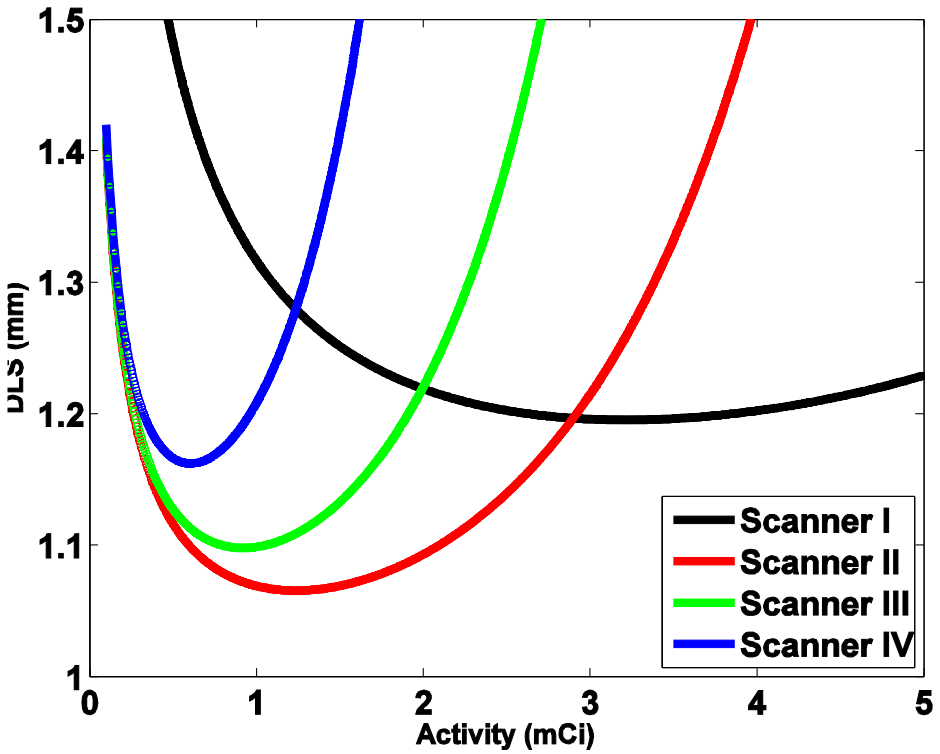
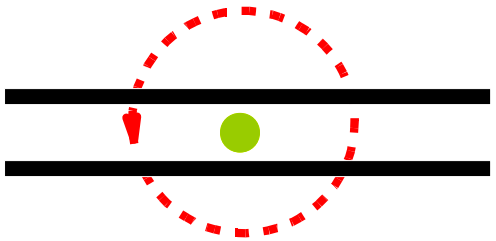
Significance of high sensitivity





A simple concept

(a)

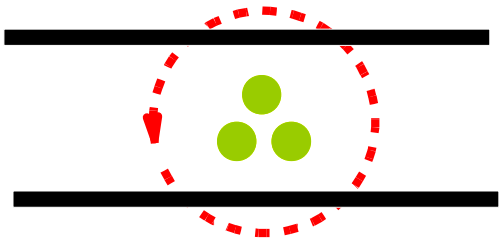


high sensitivity
high scatter
high randoms
single subject
complete data

(b)

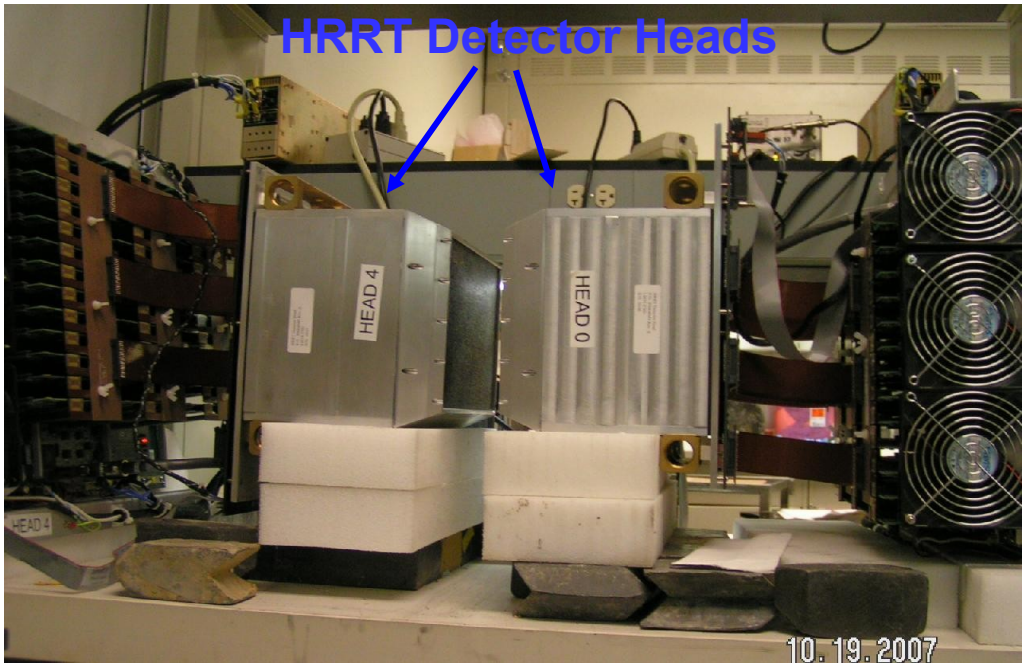
high sensitivity
high scatter
high randoms
multiple subjects
incomplete data?

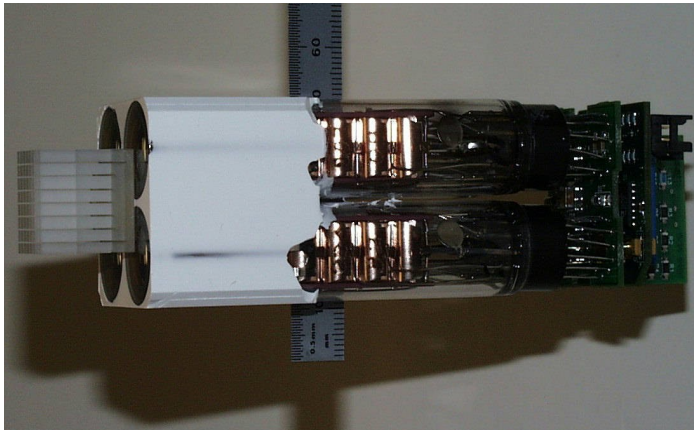
(c)



reduced sensitivity
reduced scatter
reduced randoms
complete data

A Table-Top Prototype

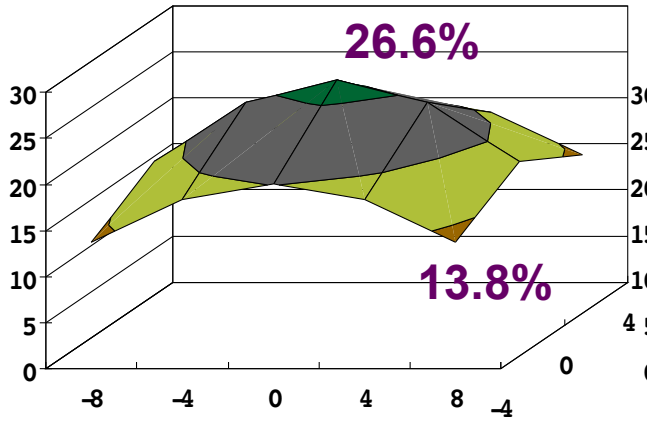




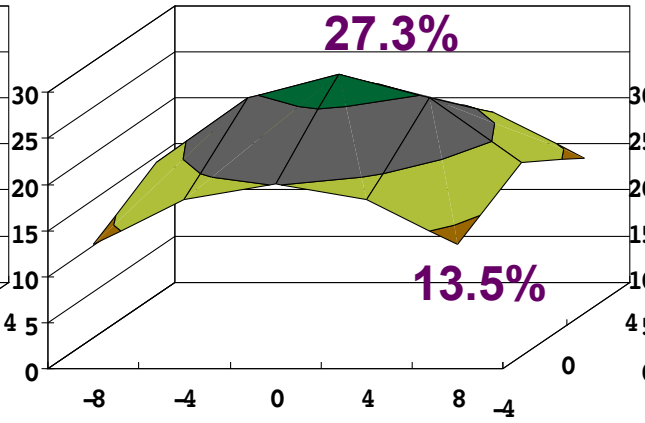
- 104x72 LSO/LYSO dual-layered crystals, 2.1x2.1x20mm^3 in size, binary DOI, quadrant-sharing
- Covers ~80% solid angle with 5cm spacing, ~38% central sensitivity

Scanner Sensitivity

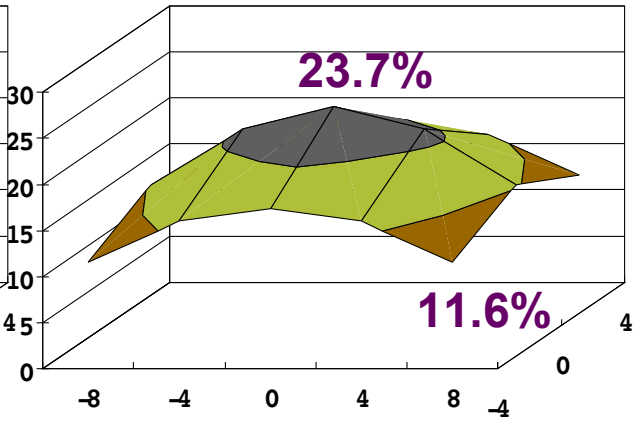
@Central plane, CW=10ns



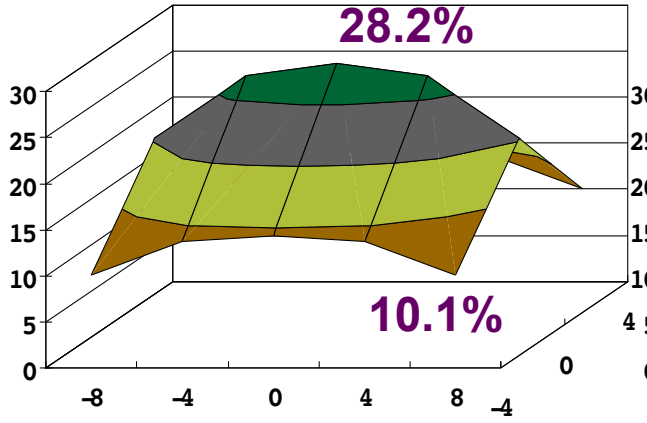
200-750 keV

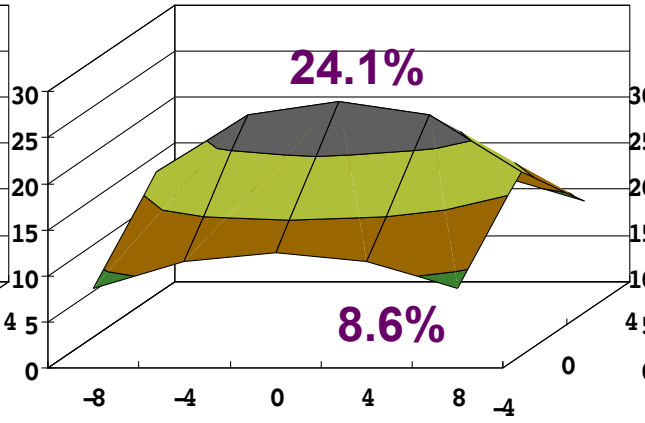


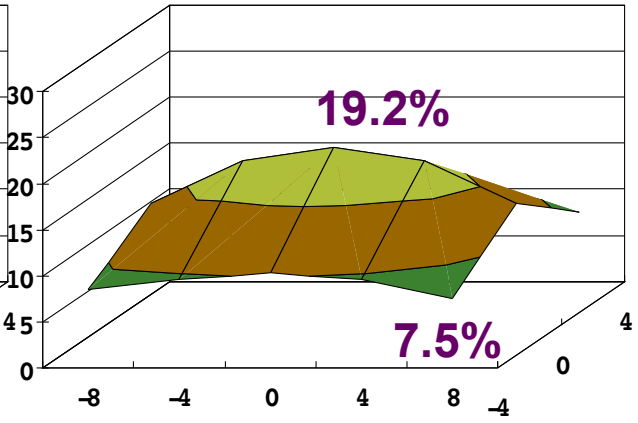
250-750 keV



300-750 keV

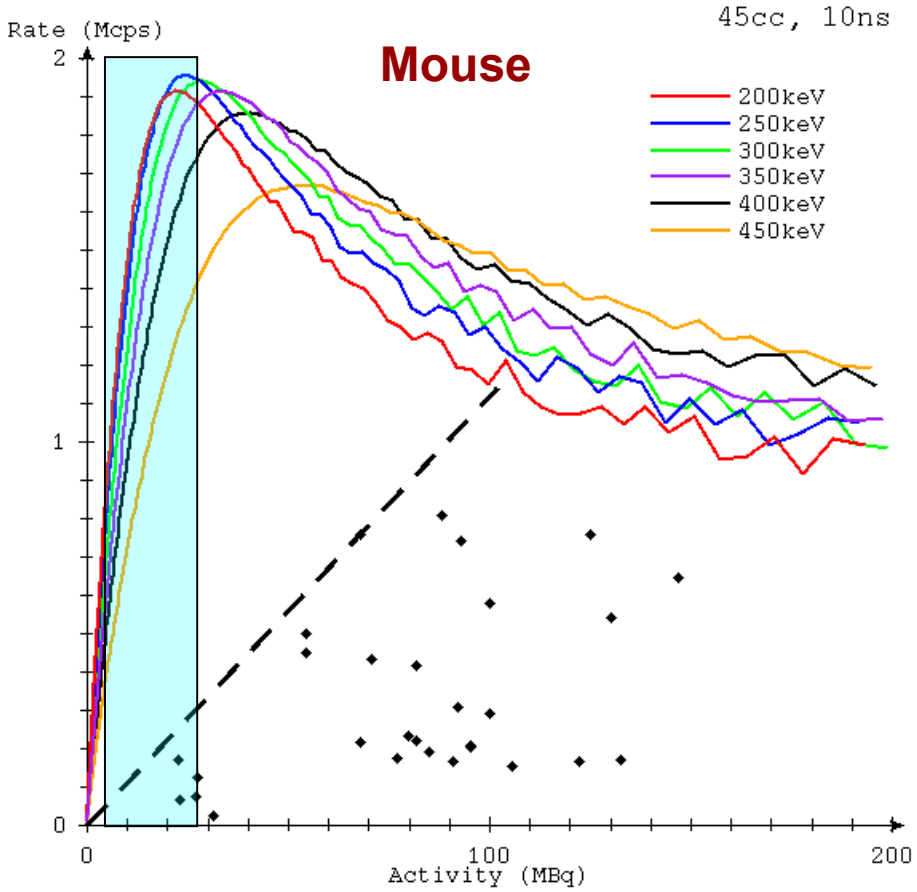


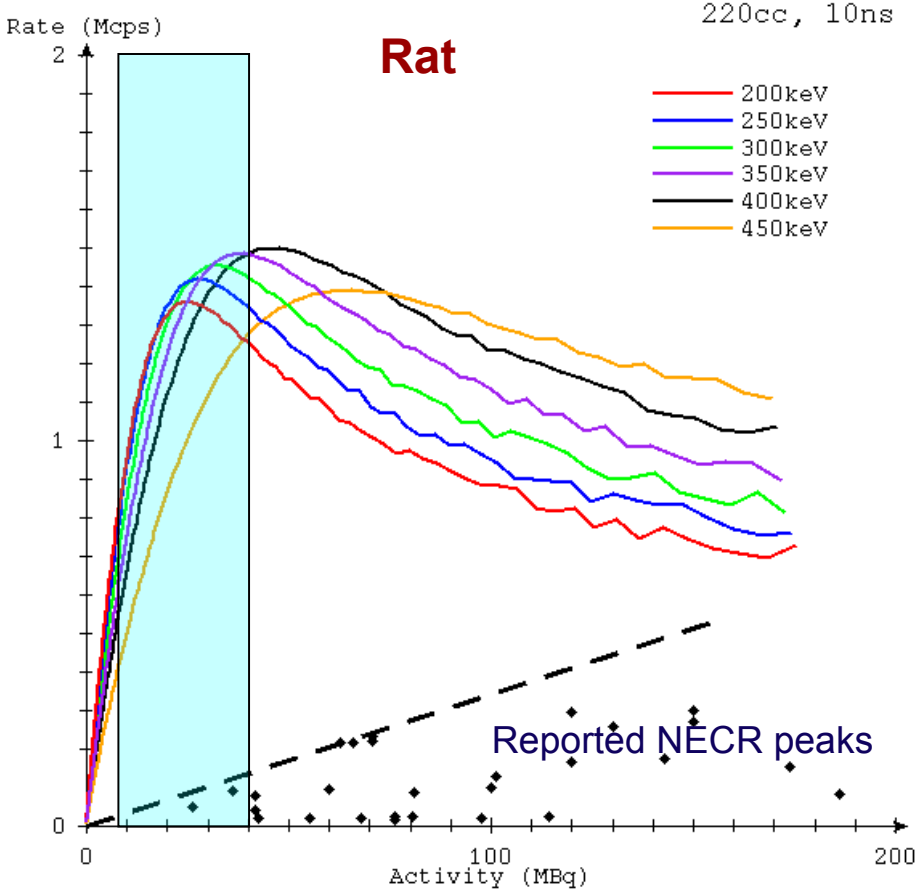




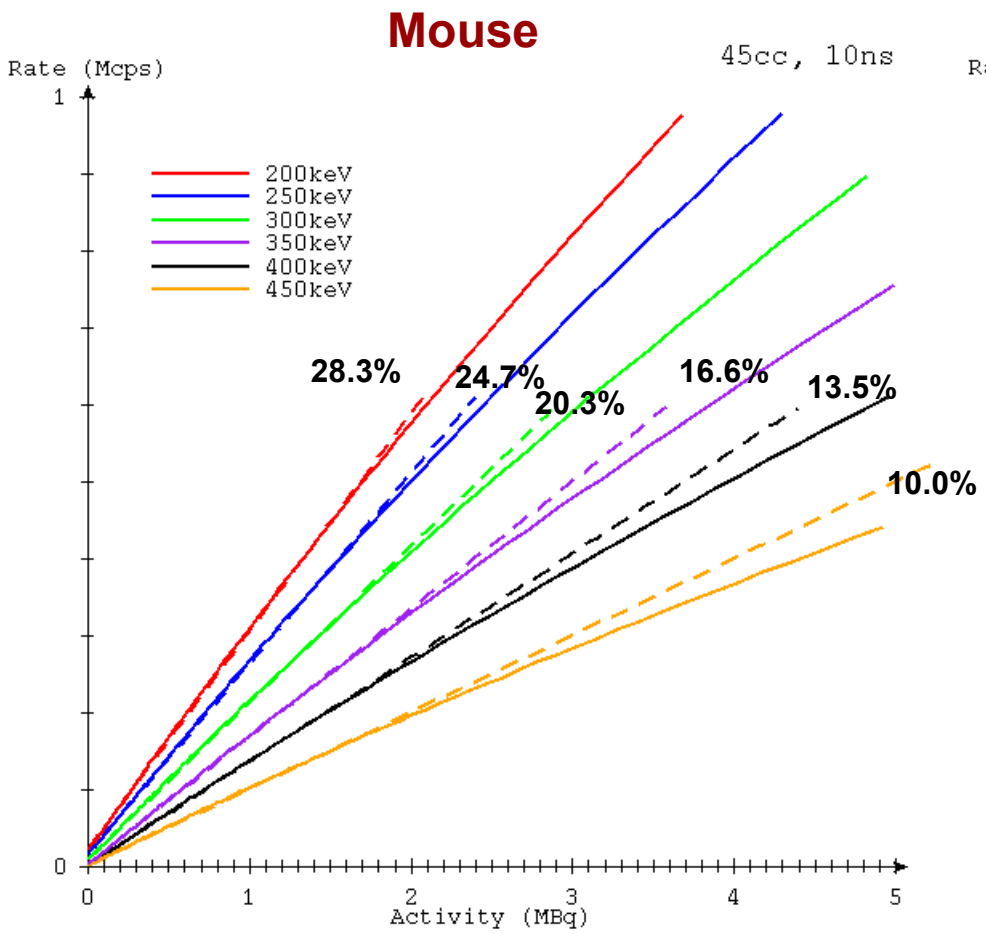
Noise-Equivalent Count Rate

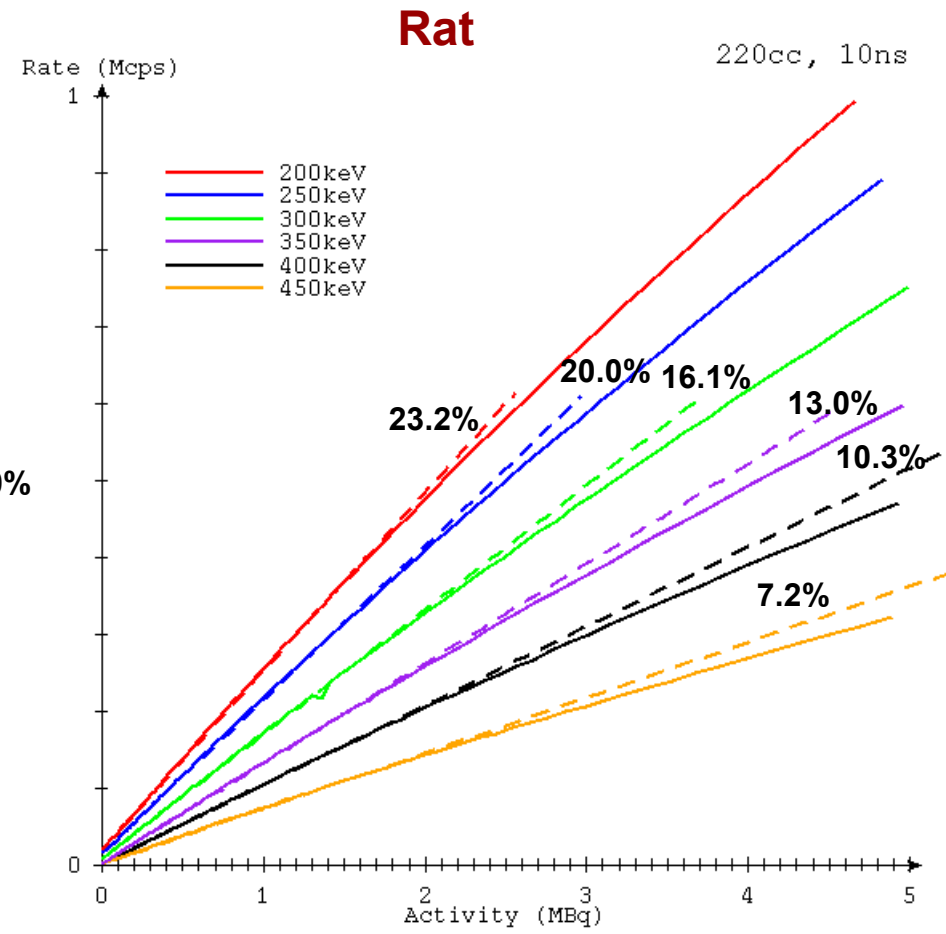
Comparison with reported NECR peaks





Noise-Equivalent Sensitivity

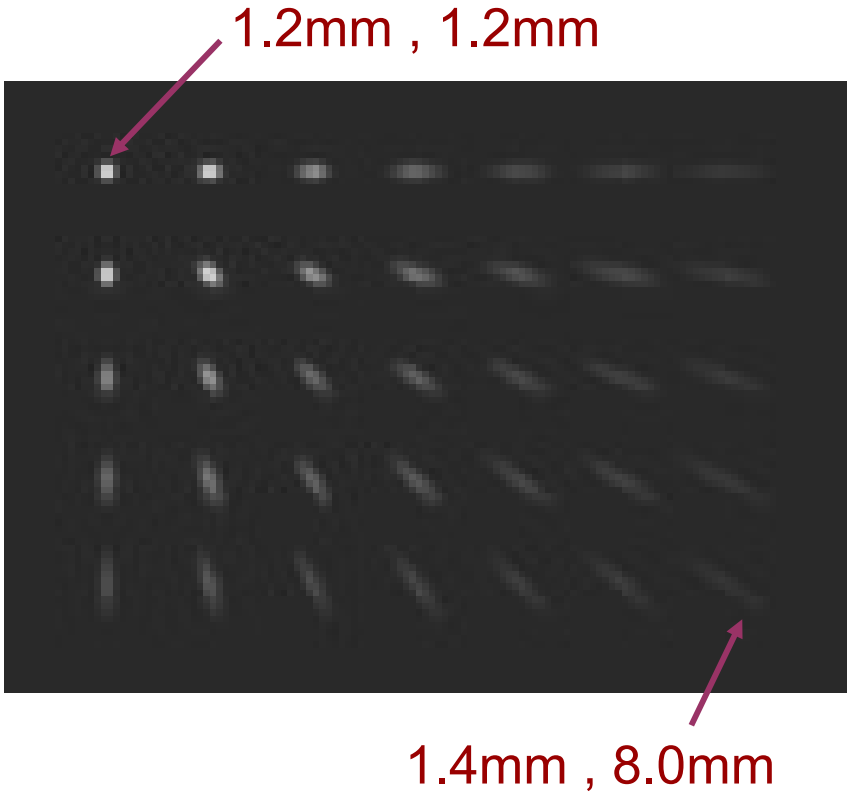


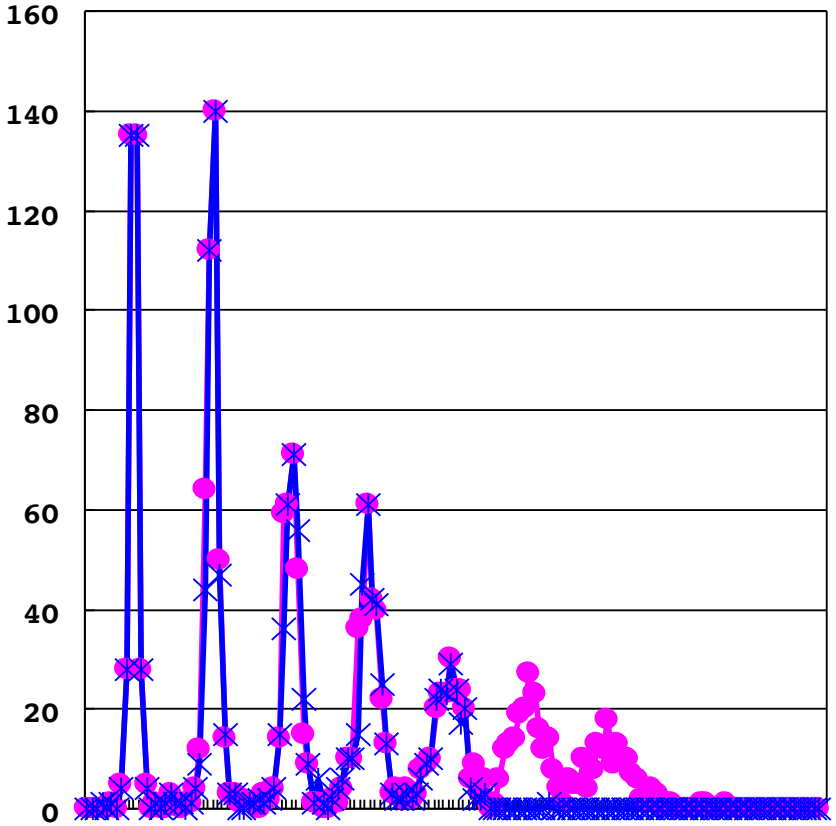


Parallax Errors (DOI blur)

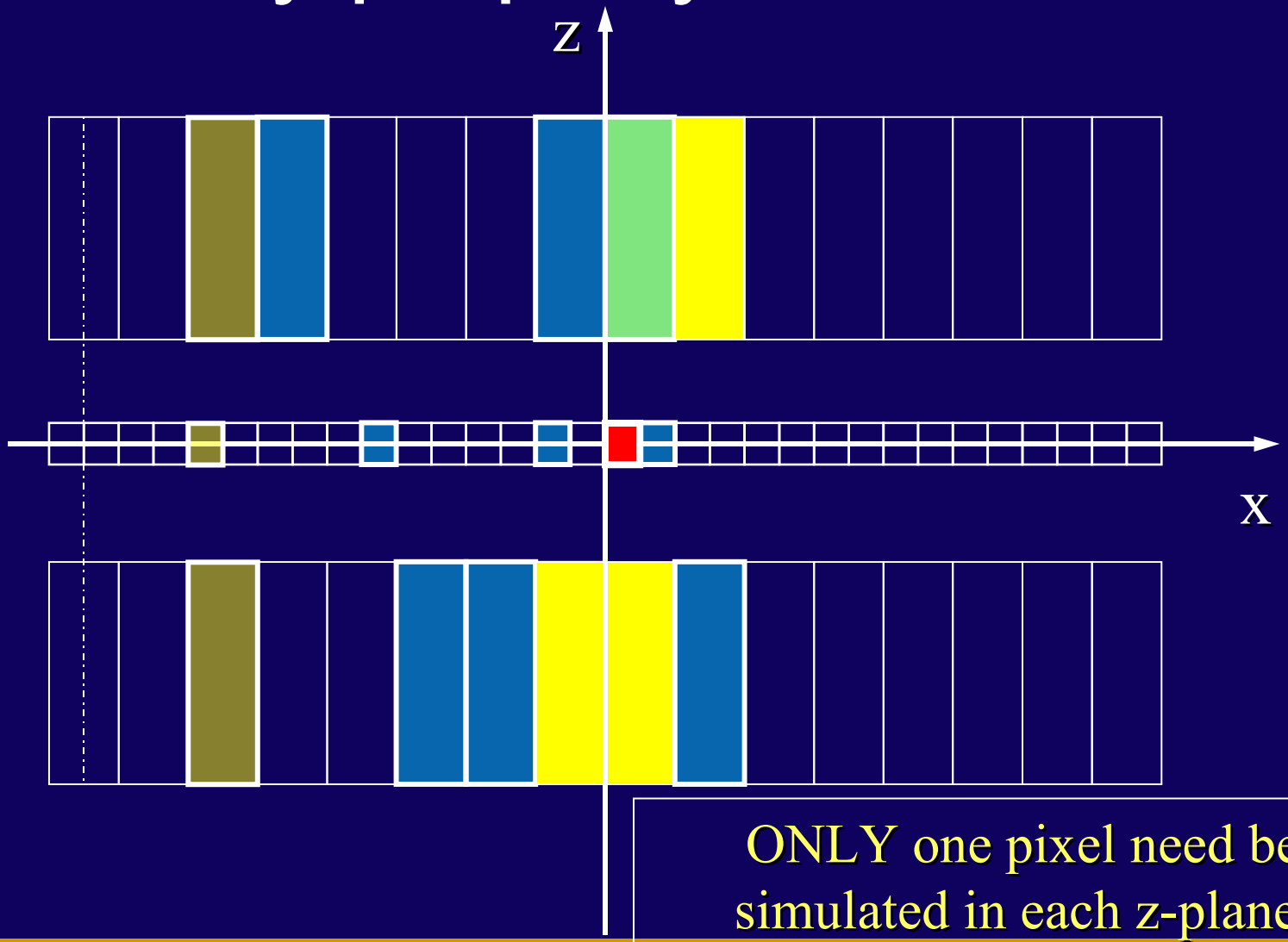
Sensitivity function @central plane

Front-front layer





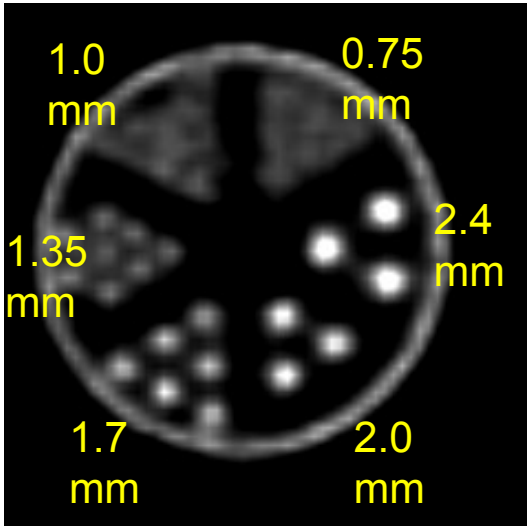
Symmetry property



ONLY one pixel need be simulated in each z-plane.

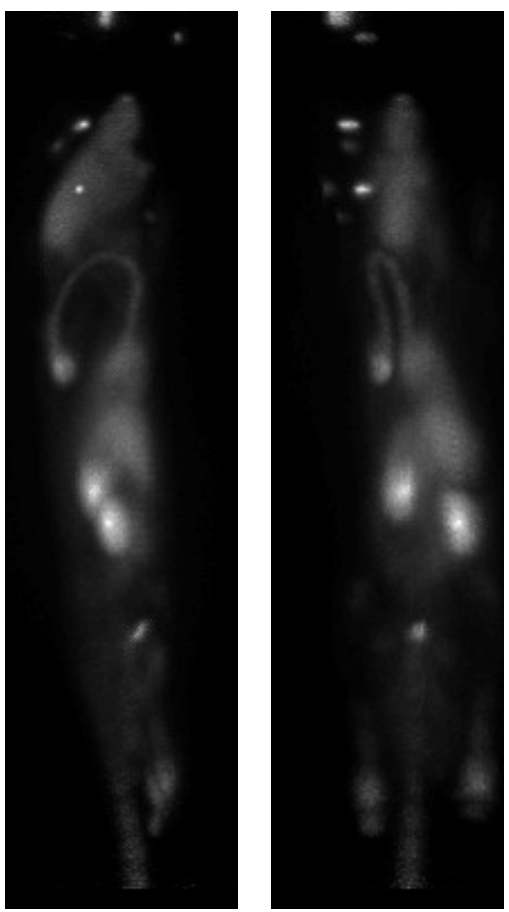
FDG resolution phantom

Ideal line integral

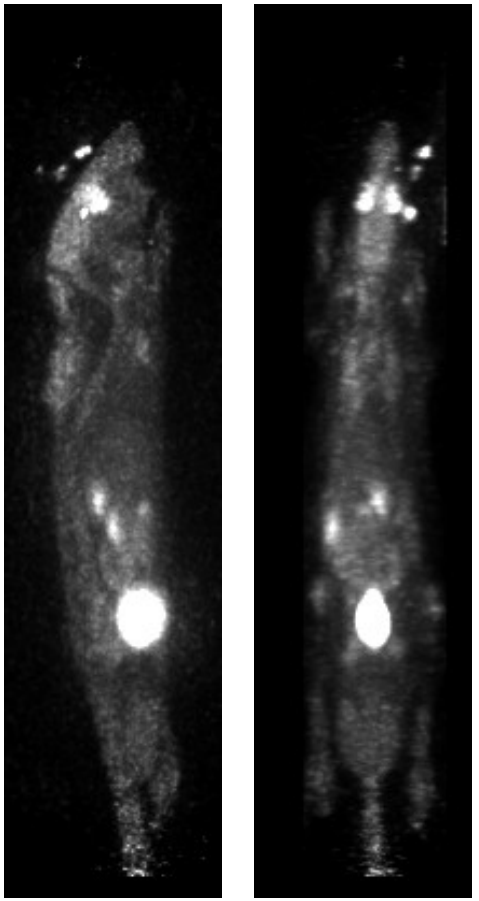


Modeling the responses by MC simulation

Initial FDG-rat images

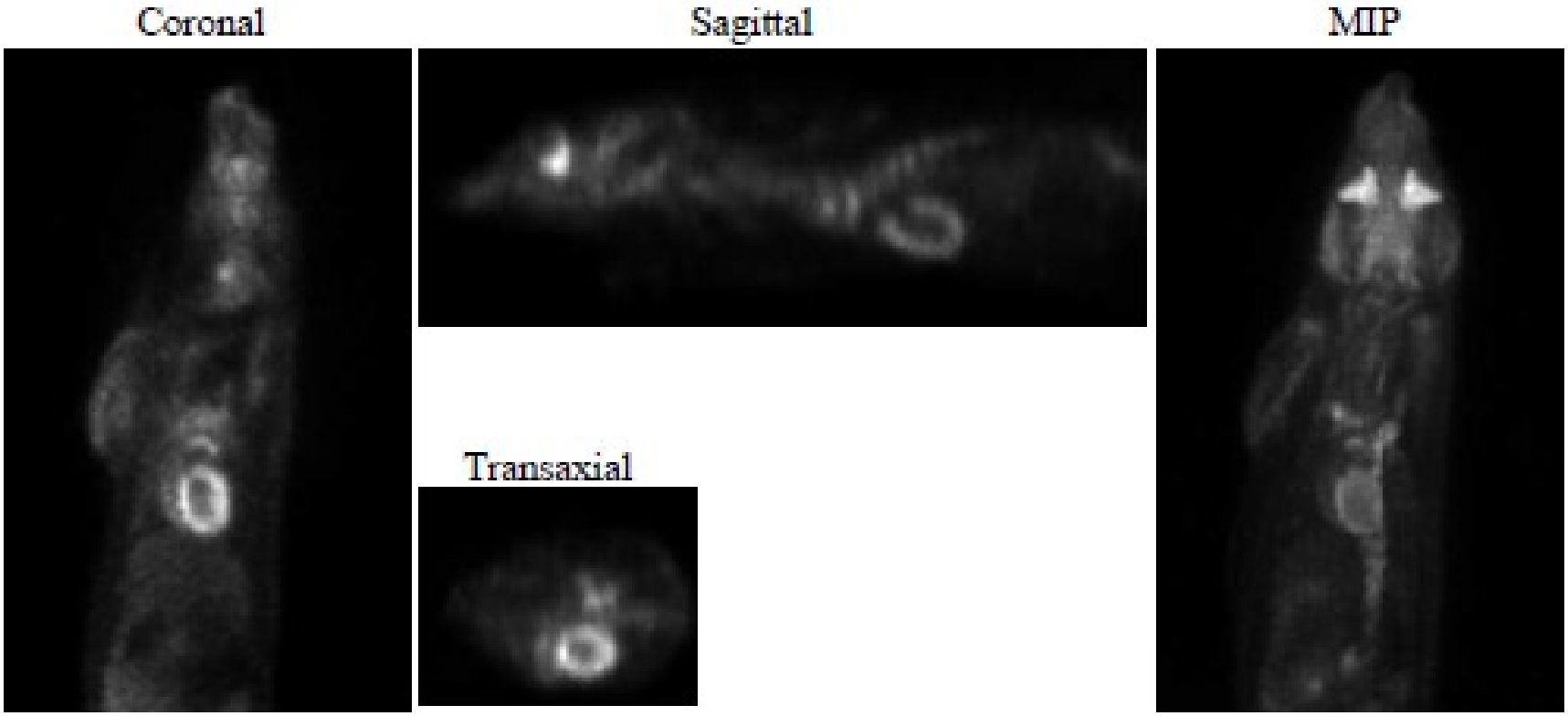


Ideal line integral

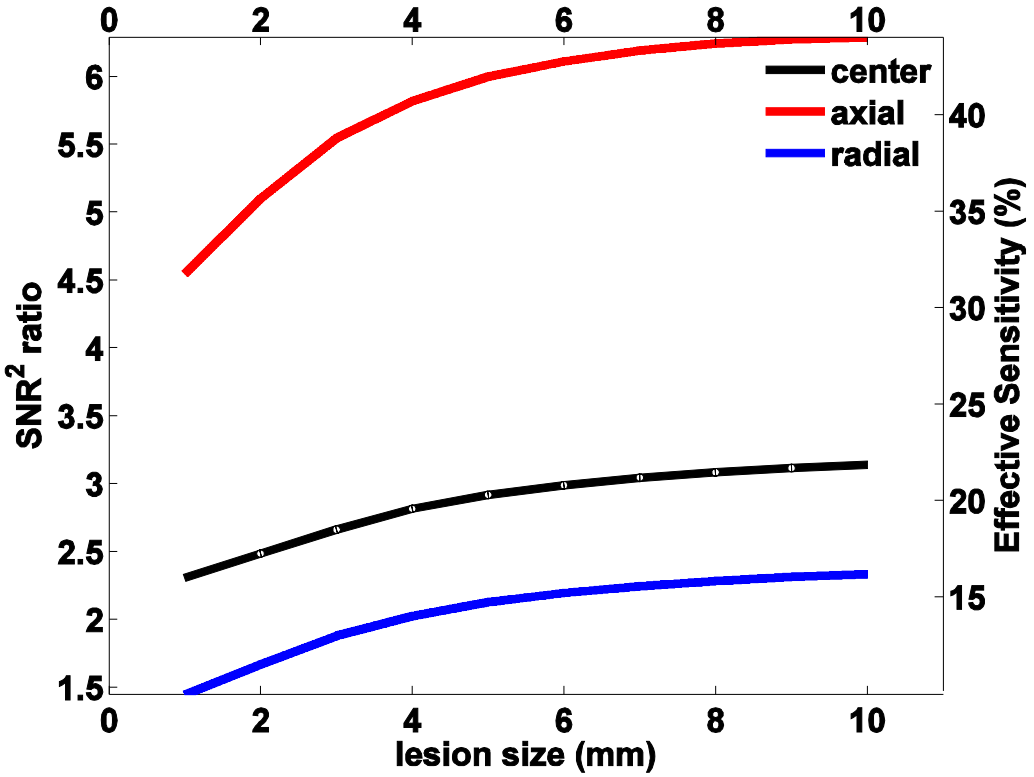


Modeling response

Initial FDG-rat Images

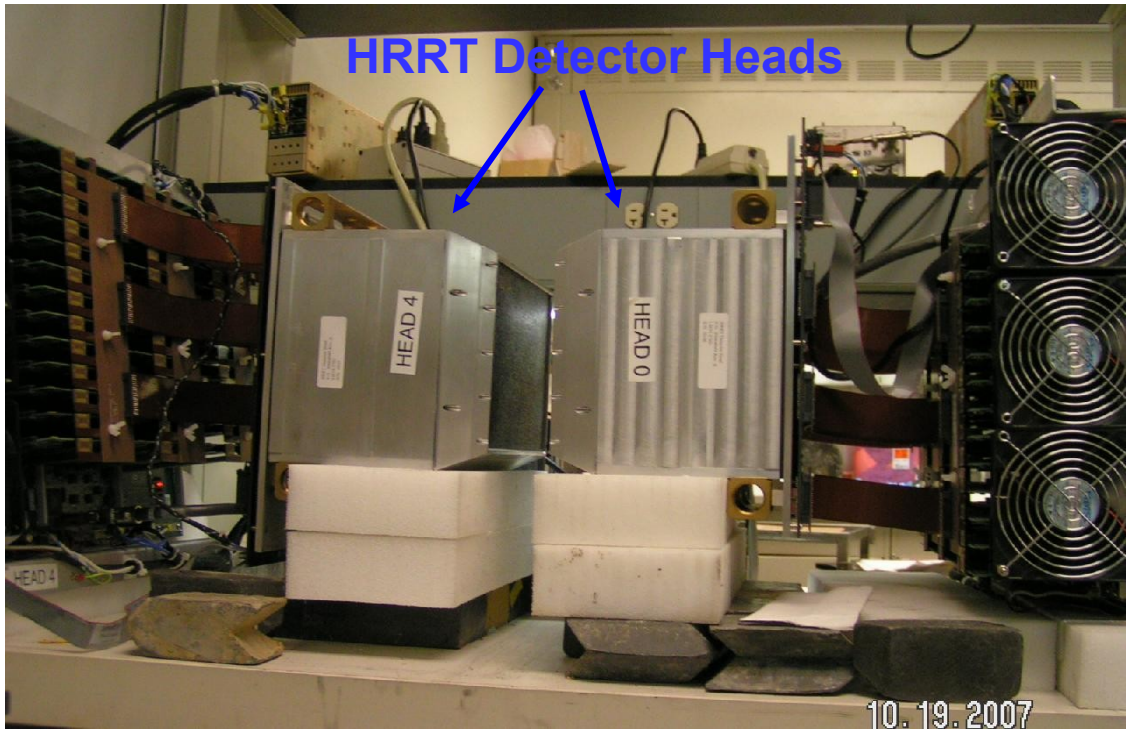


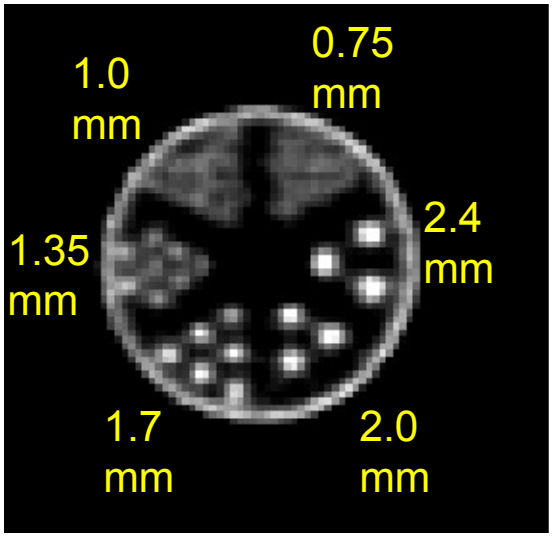
Effective sensitivity

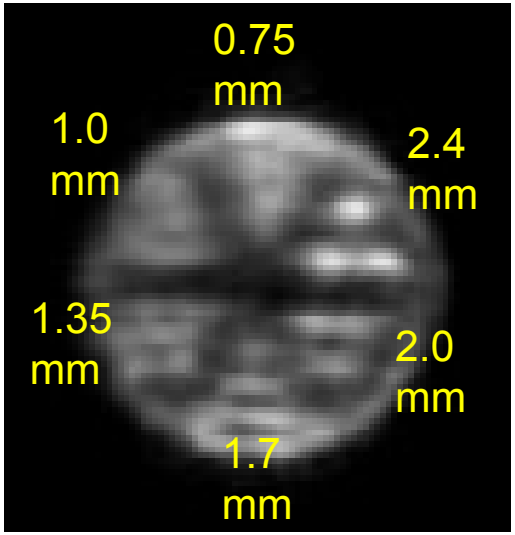


Reference system: microPET FOCUS geometry, 7% quoted central sensitivity, 1.35mm stationary resolution

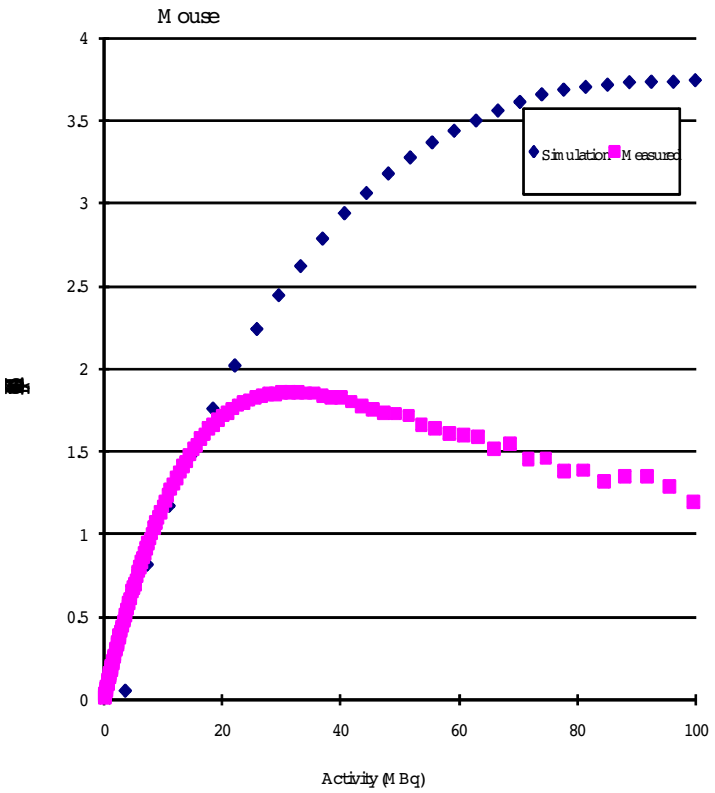
Challenges

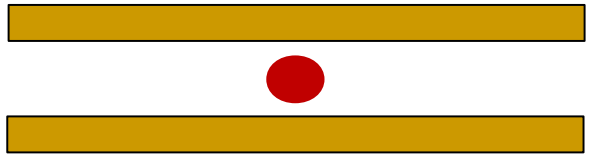

HRRT Detector Heads
HEAD 4
HEAD 0
10.19.2007

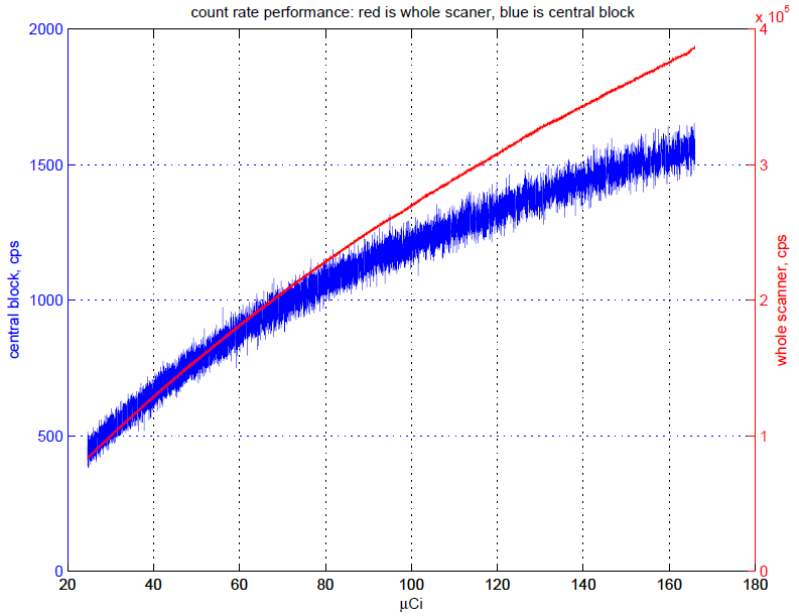

1.0 mm
0.75 mm
1.35 mm
2.4 mm
1.7 mm
2.0 mm


0.75 mm
1.0 mm
2.4 mm
1.35 mm
2.0 mm
1.7 mm

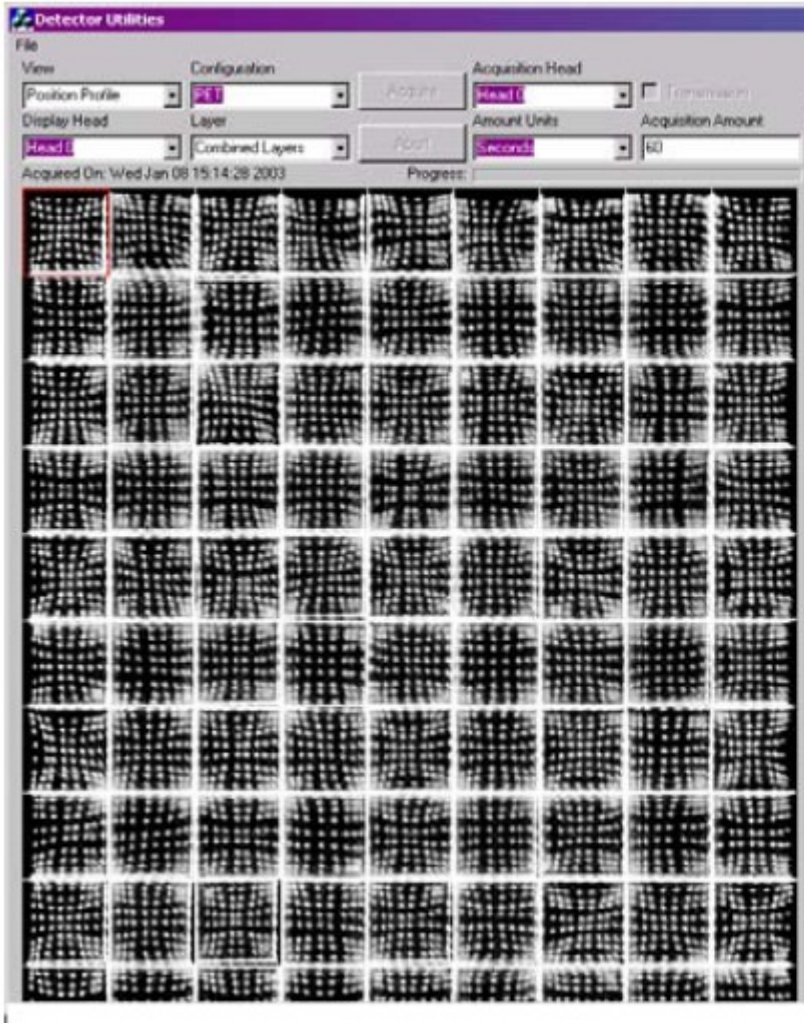
Challenges (cont'd)

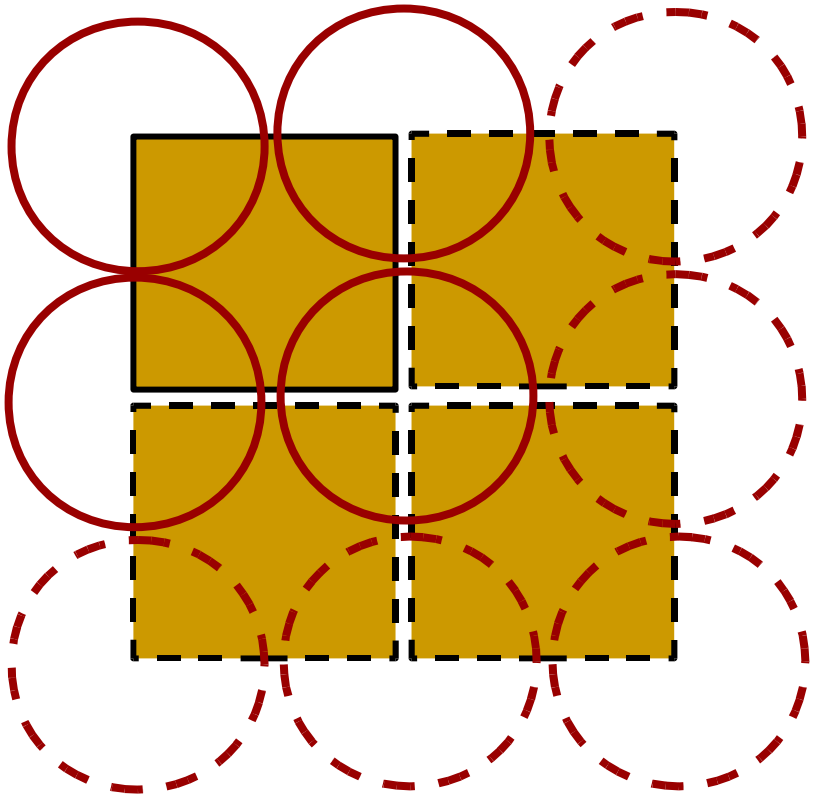




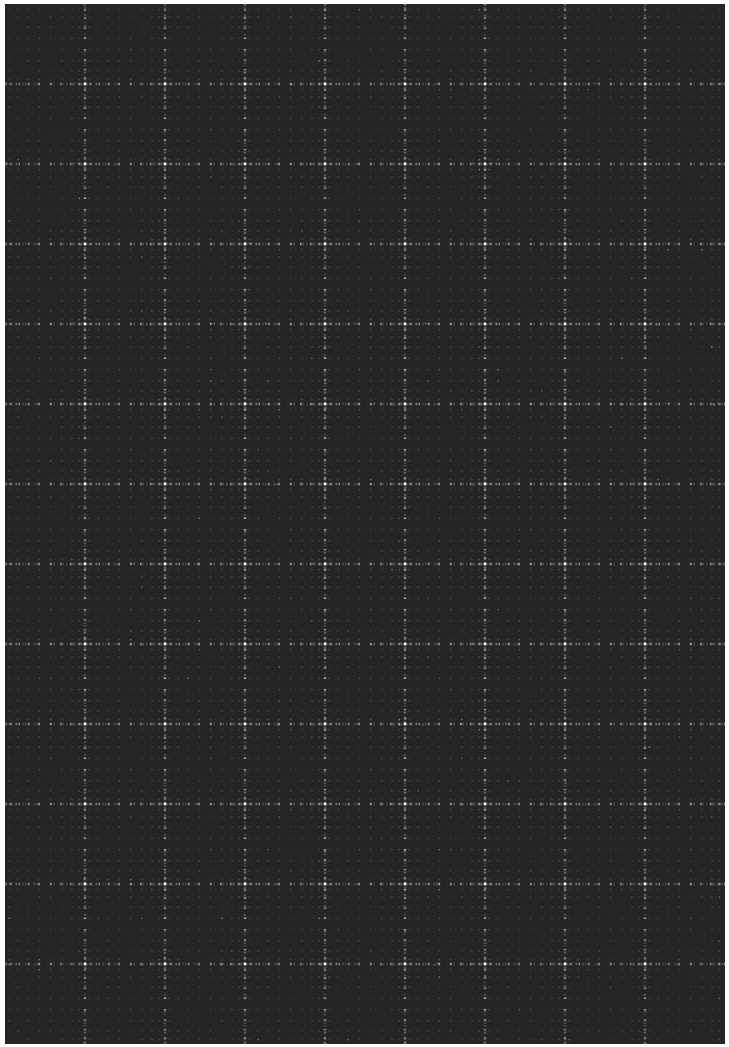


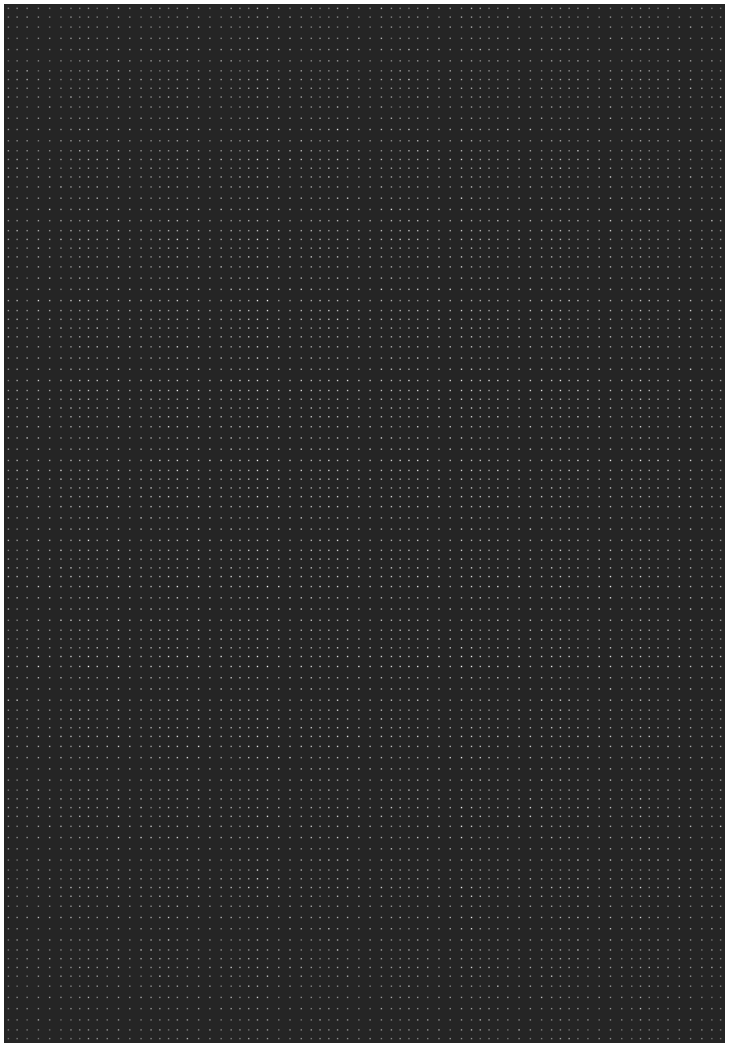
Challenges (cont'd)





Challenges (cont'd)





Summary & Conclusions

- High sensitivity and NECR at low activity
  - Reduced dose in imaging
  - Better contrast-to-noise ratio, lower tracer concentrations
  - Improved temporal resolution
  - Following tracers over a longer period of time
- Image spatial resolution through accurate image reconstruction
- High effective sensitivity can be achieved
- Challenges: resolution normal to detectors; count-rate performance; cross-talk in PQS